NUTRITION KNOWLEDGE AMONG CHILDREN FROM LOW SOCIOECONOMIC FAMILIES AND ITS RELATIONSHIP TO HEALTH-RELATED FITNESS, PHYSICAL ACTIVITY KNOWLEDGE, AND METABOLIC HEALTH

by

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STATEMENT OF THESIS APPROVAL

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ABSTRACT

Currently, approximately 17% of all children in the United States are classified as obese. Low socioeconomic status and minority populations are at significantly increased risk of obesity and incidence of metabolic disorders. Schools offer an opportunity to increase nutrition and physical activity knowledge through comprehensive school-based interventions. Presently, there are no studies evaluating the change in student nutrition knowledge following a Comprehensive School Physical Activity Program (CSPAP) intervention or comparing the relationships of nutrition knowledge to other health parameters. The purpose of this study was to compare the relationships among nutrition knowledge, health-related fitness, physical activity knowledge, and metabolic health in students in minority, low socioeconomic elementary schools. The study populations were 377, 800, and 101 students in grades 1-4, K-6, and 4-6, respectively, depending on the specific aim analysis. All students were from one of five Title I schools, with funding from the Carol White Physical Education Program Grant, in the Salt Lake City River District, using data from both the 2014-2015 and 2015-2016 school years. Knowledge assessments were collected at the beginning of physical education classes. Health-related fitness measures were obtained during another physical education class, while metabolic health measures were collected in the morning before the start of school. The change in nutrition knowledge following a minimal nutrition intervention was assessed using paired t-tests, while the relationships of nutrition knowledge and other health parameters were

evaluated using Pearson's correlation coefficients. Nutrition knowledge scores increased significantly ($p<0.001$) from pretest to posttest (Mean difference=1.01; $d=0.39$) following the CSPAP intervention. Higher nutrition knowledge scores were associated with increased aerobic fitness ($r=0.121$; $p<0.001$), increased physical activity knowledge ($r=0.458$; $p<0.001$), and lower metabolic syndrome scores ($r=-0.247$; $p=0.013$). This study highlights the importance of nutrition knowledge and comprehensive school-based interventions in this low socioeconomic, minority population. Future research on the evaluation of comprehensive nutrition interventions is needed.

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INTRODUCTION

Background/Literature Review

Childhood obesity is a major public health concern, with nearly 17% of all children in the United States classified as obese.[1-6] The prevalence of childhood obesity has almost tripled since the 1970s.[1, 3, 5, 7, 8] This increased prevalence is associated with elevated risk for chronic diseases, such as asthma, type 2 diabetes mellitus, cardiovascular disease, and several cancers.[2, 4, 6, 7, 9-12] Furthermore, overweight and obese children are at an increased risk for anxiety, bullying, and depression.[2, 13-17]

Studies indicate that children of low socioeconomic status (SES) and minority groups are at significantly increased risk of obesity.[6, 12, 13, 18-21] Additionally, Burns et al. reported that low SES children have a higher, and often earlier, incidence of metabolic disorders, blood sugar abnormalities, and cardio-metabolic risk.[18] Jin and Jones-Smith conducted a study involving eight racial/ethnic groups, and found that the prevalence of obesity was significantly higher in children with a lower family income when compared to children from higher-income families across all racial/ethnic groups.[6] This same study found that approximately 75% of Hispanic and 67% of African American children were designated as low SES, in contrast to only 24% of non-Hispanic white children, clearly showing that minority populations are often low in socioeconomic status as well.[6] Multiple studies report that there are significant differences in the prevalence of obesity associated with race and ethnicity, highlighting the fact that simply addressing income inequalities does not fully address the increased risk for childhood obesity.[8, 13, 21]

Schools are a logical site for childhood obesity prevention initiatives due to the sheer number of children enrolled in school and the ability to influence the development of healthy behaviors through education.[10, 11, 22, 23] Specifically, schools provide the opportunity to increase nutrition and physical activity knowledge in large numbers, while giving the students a chance to put their knowledge into practice for lifelong behavior change.[10, 11, 14, 22, 23] The knowledge and behaviors learned in school, at an early age, potentially decreases the overall risk and prevalence for overweight and obesity in adulthood.[11, 14, 22] Furthermore, research indicates that children are more susceptible to outside influences at a younger age, a time when many habits and preferences are established, making elementary school-based interventions essential.[2, 7, 10, 14]

Comprehensive school-based interventions focused on nutrition education and physical activity are an effective way to address rates of childhood obesity and subsequent health problems.[5] In a meta-analysis conducted by Sobol-Goldberg, Rabinowitz, and Gross, results indicated that school-based obesity prevention programs were significantly effective in reducing body mass index (BMI) across the studies (n=32) that were evaluated.[5] The majority of these studies focused on increasing physical activity and healthy eating while decreasing sedentary activities and unhealthy eating habits, finding that long-term interventions with parent involvement were associated with the most success in the change of behaviors.[5] Additionally, Rosário et al. implemented a program based on the promotion of healthier, more active lifestyles by encouraging students to be more active and to make better food choices via activities and lessons provided by trained teachers.[14] Results showed that there was a lower incidence of overweight and obesity in the intervention schools, documenting its effectiveness.[14] This program targeted the teachers as the key leaders in the intervention and included teacher training as part of required professional development, adding a much-needed incentive that many programs are lacking.[14] Jordan et al. evaluated the effectiveness of the Gold Medal Schools program in the state of Utah.[11, 24] The ongoing Gold Medal Schools program integrates the state core curriculum for health with "the CDC's school health indicators, the Healthy People 2010 Objectives, and the Division of Adolescent and School Health's School Health Index" to establish policies and environments that increase the opportunities for healthy food choices, consistent physical activity, and tobacco prevention.[11] The study results indicated that the Gold Medal Schools program had a positive impact on the BMI *z* scores and health behaviors in participating elementary school children.[11] In several other studies, it has been found that school-based interventions are effective in teaching lifelong habits and behaviors towards nutrition and physical activity that continue from childhood into adulthood.[10, 14, 22, 23] Collectively, comprehensive school-based health programs have been found to be the most successful in developing healthy behaviors and decreasing the prevalence of obesity because the children are empowered with knowledge, attitudes, and skills, while creating an environment that elevates motivation and provides support for lifestyle change.[5, 11, 14, 22]

Recurring themes in the literature are the lack of student nutrition knowledge, as well as the absence of incentives to implement school-based nutrition and physical activity programs. Multiple studies report that enhancing nutrition knowledge is an essential tool for promoting dietary behavior changes, increasing overall health, preventing weight gain, and developing improved physical activity habits.[10, 14, 19, 23]

Despite proven effectiveness, there are barriers to the development and implementation of these types of programs.[14] Main deterrents include cost, lack of time, support, resources, and common core curriculum formative assessments and demands.[14, 25, 26]

Let's Get Fit to Learn is a comprehensive school-based program targeting nutrition and physical activity. This program aims to promote nutrition education and physical activity in five Title 1, inner-city elementary schools in Utah with the Comprehensive School Physical Activity Program (CSPAP) approach.[27] This project is funded by the Carol M. White Physical Education Program Grant and provides training for all of the physical education (PE) teachers and classroom personnel at the five target schools, influencing over 2800 students.[27] This program addresses the lack of student nutrition knowledge and absence of incentives for implementation by developing a nutrition education intervention and providing resources and personnel for program implementation.[27] CSPAP is designed to meet the Absolute Priorities of the grant and to increase the implementation of state standards for health and physical activity.[27] The two main program goals are to: 1) improve "the knowledge, skills, behavior, and attitudes of students toward healthy eating and physical activity; [and] 2) to build a comprehensive model for a school and Community Learning Center-based wellness program" to meet state standards as well as dissemination on a wider scale, such as the district and state level.[27]

Significance of Problem

To date, there are few studies evaluating the impact of a school-based intervention on promoting gains in nutrition knowledge. To our knowledge, there is no published research evaluating the change in student nutrition knowledge following a CSPAP intervention or comparing the relationships of nutrition knowledge to other health parameters such as body composition, aerobic capacity, physical activity, physical activity knowledge, and metabolic health measures, in a low SES, minority population. As documented, nutrition knowledge can be vital to improving dietary changes and physical activity habits, as well as decreasing the prevalence of overweight and obesity, which could be profound in low SES and minority populations due to increased obesity rates.[10, 14, 19, 23] Therefore, more research is needed to evaluate the effect of a CSPAP approach on nutrition knowledge and to determine the relationship of nutrition knowledge to other health measures.

Purpose and Hypotheses of Research

The purpose of this study was to compare the relationships among nutrition knowledge, health-related fitness, physical activity knowledge, and metabolic health in students in low socioeconomic elementary schools.

The specific aims for study were:

1. To analyze two nutrition knowledge survey scores from students (n=377), grades 1-4, who attend one of three Title I schools in the Salt Lake City River District to determine if a significant difference exists between the nutrition knowledge survey scores conducted in January 2015 and the scores collected in May 2015.
2. To compare the relationships among nutrition knowledge survey scores, health-related fitness measures, which include aerobic capacity and body composition, and physical activity measures collected in Fall 2015, in students (n=800) in grades K-6 from all five schools.
3. To compare the relationships among nutrition knowledge survey scores, physical

activity knowledge test scores, and metabolic health measures collected in the Fall 2015, in students (n=101) in grades 4-6 from all five schools.

For the first specific aim, we hypothesized that the nutrition knowledge survey scores would significantly increase from the initial test in January 2015 to the retest date in May 2015. To note, there was minimal nutrition education occurring through CSPAP during this time. However, we assumed there would be an increase in test scores due to the minimal intervention from teachers and certified specialists.[27] The null hypothesis for this research was there would not be a significant increase between these two survey scores. For the second specific aim, we hypothesized that increased nutrition knowledge would have a positive relationship with aerobic capacity and physical activity, and a negative relationship with body composition. The null hypothesis for this aim was that there would be no or a negative relationship with aerobic capacity and physical activity, and no relationship or a positive relationship with body composition. For the third specific aim, we hypothesized that higher nutrition knowledge scores would be associated with lower Metabolic Syndrome (MetS) scores and higher physical activity knowledge test scores. The null hypothesis for this research was that higher nutrition knowledge scores would not be associated with lower MetS scores or higher physical activity knowledge test scores.

METHODS

Participant Selection Criteria

Participants were elementary school students in kindergarten through sixth grade, from one of five Title 1 schools in low socioeconomic status, inner city neighborhoods from the state of Utah.[28] The students were recruited based on enrollment in a school district that received funding from the U.S. Department of Education in the form of a Carol White Physical Education Program (PEP) Grant.[28] According to the State Department of Education and the school district website, 91- 96% of the children at each of the three schools were from low-income families during the 2014−2015 school year, while 72-81% of the children from all five schools were from low-income families during the 2015-2016 school year (http://www.schools.utah.gov/data/).

A subset population, which included students (n=377) from Mountain View, Rose Park, and Lincoln in the 1st through 4th grades who completed two nutrition knowledge surveys, were selected to analyze changes in nutrition knowledge over the time period of January 2015 to May 2015. A second subset population from all five schools consisted of a convenience sample of children who were recruited from the 3rd through 6th grades; however, in order to compare the desired relationships among nutrition knowledge, physical activity knowledge, and metabolic health measures, only students (n=101) from the 4th through 6th grades were included.

Prior to data collection, written assent was obtained from the students and written consent was obtained from the parents. The study protocols were approved by the University of Utah Institutional Review Board for Human Subjects.[18]

Description of the CSPAP Nutrition Intervention

The nutrition intervention was simple, incorporating several different modes and environments. The intervention occurred from January 2015 to May 2015 at Mountain View, Rose Park, and Lincoln elementary schools. Physical Activity Leaders, who are assigned to a specific school, posted signs with nutrition information along a walking path that encompassed the school grounds at their respective schools, varying in length. Classroom teachers provided brief nutrition information during classroom breaks varying in length from five to fifteen minutes. Finally, the PE teachers or the Physical Activity Leader gave nutrition reminders intermittently throughout the PE classes.

Instruments and Data Collection

Knowledge Assessments

Nutrition knowledge survey. The survey, entitled Fit Kids "R" Healthy Kids, consisted of 15 multiple-choice questions to assess nutrition knowledge. The questions were evenly divided into three different domains: food groups, healthful foods, and food functions.[24] The total score was calculated by summing the amount of correct answers and the percent correct was calculated by taking the total score and dividing by 15. This survey demonstrated validity and reliability for assessing nutrition knowledge in elementary school students in grades 1 to 4 [24].

Physical activity knowledge test. SHAPE America approved the PE Metrics test, which was used to assess physical activity and physical fitness knowledge in this study.[29]

The tool is a valid and reliable assessment instrument, with the removal of three questions due to low item performance characteristics, with prior use in this age group.[30-33] For the current study, the grant research team employed the Standards 3 and 4 fifth grade test that was comprised of 28 multiple-choice questions, with 25 items included for assessment.[29, 33]

Health-related Fitness

FITNESSGRAM®. The FITNESSGRAM fitness assessment and reporting program is the national fitness test battery currently in use in the United States. The program contains validated fitness and activity based assessments for use by teachers to direct effective PE classes for their students.[34] Also, the program provides the opportunity for teachers to collect individualized and school-wide results, allowing for long-term tracking of trends and data.[34] This program uses criterion-referenced standards to classify children into Healthy Fitness Zone categories based on their performance on fitness tests.[34]

Aerobic capacity. Aerobic capacity was estimated using the 15-meter (grades 1 to 3) and 20-meter (grades 4 to 6) Progressive Aerobic Cardiovascular Endurance Run (PACER), conducted during each participant's PE class.[28, 35] For the PACER, studies report correlation coefficients ranging from $r = 0.60$ to 0.87 with measured VO^2 peak and test-retest reliability in school-aged children with intraclass coefficients ranging from $r = 0.82$ to 0.93.[28, 36-39] The PACER was administered on a marked gymnasium floor with background music and tempo provided by a compact disk. Each student was informed to run from one floor indicator to another floor indicator spanning a 20-meter distance within a designated time frame. The designated time given to reach the indicated distance incrementally lessened as the test advanced. If the student failed two times to reach the other floor indicator within the set time frame, the test was ended.[40] Although data were obtained throughout all grades, correct technique and enjoyment of the test were stressed above performance in younger kids from grades 1 to 3, given the suggestions in the FITNESSGRAM manual.[40]

Body composition. Body composition was measured using Body Mass Index (BMI). BMI was computed using standard techniques, with weight in kilograms divided by the square of height in meters. Height was recorded to the nearest 0.01 meters using a transportable stadiometer (Model 213, Seca, Hanover, MD) and weight was measured to the nearest 0.1 kilograms using a transportable medical scale (Model BD-590, Tanita, Tokyo, Japan). The students' shoes were removed but clothes remained on during the height and weight assessments.[18]

Physical Activity

Pedometers. Physical activity was tracked using Yamax DigiWalker CW600 pedometers (Tokyo, Japan). The devices were worn for five days at school (Monday through Friday) between the hours of 8:00 am and 3:00 pm. Pedometers were worn on the hip, even with the iliac crest, over the knee on the right hip.[28] Classroom teachers, physical educators, and research team members confirmed that the devices were worn during the entire school day.[29] The pedometers contained a seven-day memory that was used to report steps each day of the school week. Research indicates that Yamax DigiWalker models produce an accurate recording of steps within ± 3% of actual steps, as a valid assessment of free-living physical activity.[29, 41, 42]

Metabolic Health

Cardio-metabolic measures. Participant cardio-metabolic profiles were obtained via the Cholestech LDX system (Alere Inc., Waltham, MA). Individual measurements included total cholesterol (TC), LDL cholesterol, HDL cholesterol, triglycerides (TRI), and blood glucose (BG). A capillary blood sample was obtained between the hours of 6:00 am and 8:00 am before the beginning of the school day.[18] Blood samples were obtained in a fasted state, verbally confirmed by both the student and the student's parent or guardian before the collection of the blood sample.[18] Blood samples were obtained via a finger stick on each student's right index finger using a 40-µL capillary tube, inserted promptly into the Lipid Profile-Glucose Cassette (Alere Inc., Waltham, MA), and subsequently analyzed.[18] Unfavorable cardio-metabolic results were defined as TC $\geq$ 200 mg/dL, LDL $\geq$ 130 mg/dL, HDL $<$ 40 mg/dL, TRI $>$ 150 mg/dL, and BG $\geq$ 100 mg/dL (pre-diabetes).[18]

Waist circumference. Waist circumference was measured by taking an abdominal circumference measurement at the level of the superior border of the iliac crest on the right side using a standard measuring tape.[43] All measurements were estimated to the nearest 1 cm.[43]

Blood pressure. Blood pressure was measured using an electronic blood pressure device (CONTEC08A, Contec Medical Systems Co., Qinhuangdao, China). Systolic blood pressure (SBP) and diastolic blood pressure (DBP) measurements were taken on the right arm with the right arm resting on the table and both feet on the ground.

Procedures

Students in grades K-6 completed the nutrition knowledge survey on three occasions, January, May, and September 2015, each at the beginning of a physical education class, with the CSPAP initiated in between January and May. Each question and answer was read aloud to the students, allowing about 20-30 seconds response time for each question.

On a separate day, research team members conducted the physical activity knowledge test at the beginning of a PE class. A detailed protocol was followed, where each question and answer was read aloud to the schoolchildren in grades 4 to 6, giving about 20-30 seconds response time for each question.[29]

For health-related fitness, participants were randomly designated to four stations and completed assessments at each individual station during PE class. The four stations included the PACER, anthropometric measurements (i.e., height and weight), curl-ups, and pushups. At least 5 minutes was given in between successive fitness tests to provide for recovery. A qualified member of the research team (Physical Activity Leader, Research Associate, or Graduate Research Assistant) obtained all measures to maintain testing accuracy and consistency.[28] Pedometers were distributed no less than one week and no more than three weeks after motor skill or health-related fitness testing at each school using the above procedures to track physical activity throughout the school day.[28]

Metabolic health was collected as outlined above. The Metabolic Syndrome Score, a continuous metabolic syndrome composite score (MetS), was calculated using each child's fasting triglycerides, blood glucose, HDL cholesterol, waist circumference, SBP, and DBP.[44] An estimated mean arterial pressure (MAP) score was calculated from

SBP and DBP values using the equation: MAP = ((2 × DBP) + SBP) ∕ 3.[44] The MAP score was used for derivation of MetS because it incorporates both SBP and DBP into a single measure. Derivation of the MetS scores included calculating an individual standardized score (z-score) per measure. Since HDL cholesterol is inversely related to cardio-metabolic risk, the HDL z-score was multiplied by −1. The MetS score was the sum of all calculated z-scores with a higher MetS score representing a more unfavorable cardio-metabolic profile. These procedures were in accordance to those given by Eisenmann.[44]

Design and Analysis

Research Design

The research design was two-fold based on the specific aims. The first specific aim involved a quasi-experimental research study design analyzing the change of nutrition knowledge in school children enrolled in one of three Title 1 elementary schools in the Salt Lake City River District, from January 2015 to May 2015. This change was evaluated by administering the nutrition knowledge surveys twice to students in the 1st through 4th grades.

The second and third aims involved a predictive cross-sectional study design examining the relationships among nutrition knowledge, health-related fitness, physical activity knowledge, and metabolic health in students enrolled in kindergarten through sixth grade in Fall 2015 from one of five Title 1 elementary schools in the same district.

Statistical Methods

The research data were screened and cleaned using z-scores and box plots to discover any potential outliers, and k-density plots to check normal distribution. The hypothesis that nutrition knowledge would significantly increase over time through the CSPAP intervention was tested using a paired t-test with significance set at $p < 0.0125$. The hypothesis that nutrition knowledge would have an appropriate and predictive relationship with aerobic capacity, body composition, and physical activity was tested using Pearson's correlation coefficients. The health-related fitness and physical activity measures were the predictors and nutrition knowledge was the criterion using multiple linear regression. The hypothesis that nutrition knowledge would have a positive relationship with physical activity knowledge and a lower MetS score was tested using Pearson's correlation coefficients as well. The physical activity knowledge and metabolic health measurements were the predictors and nutrition knowledge was the criterion using multiple linear regression. For the regression models, a power analysis was conducted. The sample size of n=92 to n=110 reflects 5-8 predictor variables, respectively, for a medium effect size at a power of 80%. To note, there were several assumptions with the data. First, we assumed that there would be normality among the residuals, which was tested with histograms. Second, that homoscedasticity would exist, evaluated through residual vs. fitted plots. Finally, we assumed that the data would be linearly related, which were examined by scatter plots. The data were analyzed using Stata (version 14.1, 2015, Stata, College Station, TX).

RESULTS

Change in Nutrition Knowledge: Grades 1-4

Based on the inclusion criteria, students (n=388) in grades 1-4 from Mountain View, Rose Park, and Lincoln elementary schools completed the nutrition knowledge survey in both January and May 2015. Due to outliers, 11 (2.8%) students were removed from the data set, yielding a sample of students (n=377) for analysis. The remaining data were slightly skewed, yet there were no values outside three z-scores and the box plot showed no outliers.

After a minimal CSPAP intervention, the nutrition knowledge survey scores increased significantly ($p<0.001$) from the initial test in January 2015 to the retest date in May 2015. The paired t-test showed a significant improvement in the total score ($p<0.001$), as well as each domain, including food groups ($p<0.001$), healthful foods ($p<0.001$), and food functions ($p<0.001$) (Table 1). Although statistically significant, Pearson's correlation coefficients only revealed a high correlation between initial test and retest scores for the total survey score ($r=0.49$; $p<0.001$) and food groups ($r=0.56$; $p<0.001$), with a low correlation for healthful foods ($r=0.25$; $p<0.001$) and food functions ($r=0.19$; $p<0.001$).

Nutrition Knowledge and Health-Related Fitness: Grades K-6

A total of 848 students in grades K-6 from five Title 1 schools in the Salt Lake City River District had complete data, including a nutrition knowledge survey score,

Table 1. Test-retest comparison of nutrition knowledge scores for students (n=377) in grades 1-4 from Mountain View, Rose Park, and Lincoln elementary schools.

		Initial Test		Retest		
Domain	**Possible Score**	**Mean score ± SD[b]**	**% Correct**	**Mean score ± SD[b]**	**% Correct**	r^a
Food groups	5	3.93 ± 1.32	78.60%	4.27 ± 1.13	85.40%	0.56*
Healthful foods	5	4.14 ± 1.37	82.80%	4.46 ± 1.12	89.20%	0.25*
Food functions	5	1.75 ± 1.14	35%	2.10 ± 1.25	42%	0.19*
Total	15	9.82 ± 2.67	65.40%	10.83 ± 2.42	72.20%	0.49*

[a]Pearson's correlation coefficients for mean knowledge scores from first and second survey administration
[b]SD= Standard Deviation
*p<0.001 for significant difference at retest

health-related fitness, and physical activity measures in Fall 2015. Due to outliers, 48 (5.7%) individuals were removed from the data set for a total sample of 800 students for analysis. The remaining data were found to be approximately normal with homoscedasticity. The summary statistics for each variable are reported in Table 2.

Increased nutrition knowledge had a positive relationship with aerobic capacity and body composition and a negative association with physical activity (Table 3). These results showed that as the nutrition knowledge survey scores increased, BMI and the number of PACER laps completed increased as well. In contrast, an inverse relationship was found between survey scores and average steps taken: as nutrition knowledge survey scores increased, the average number of steps taken in a school day decreased. All variables were significant (BMI: p=0.001; PACER laps: p<0.001; Average steps: p=0.017) predictors of nutrition knowledge survey scores; however, the small size of the coefficients indicated that each variable had a minimal effect on the outcome of the survey scores (Table 3). In addition, this regression model with variables of aerobic capacity (PACER laps), body composition (BMI), and physical activity (average steps) only accounted for 3.7% of nutrition knowledge survey scores, showing a small effect size. This finding was further confirmed with a Pearson's correlation test, with *rho* ranging from 0.081 (absolute value of average steps) to 0.121 (PACER laps) for all variables (Table 4).

Nutrition Knowledge, Physical Activity Knowledge, and Metabolic Health: Grades 4-6

Based on inclusion criteria, students (n=107) in grades 4-6 from the five Title I schools completed the following assessments: nutrition knowledge survey, physical

Table 2. Summary statistics of nutrition knowledge survey scores, BMI, PACER laps, and average steps for all schoolchildren grades K-6 in five Title I schools, who completed all four areas in Fall 2015.

Variable (n=800)	Mean ± SD[a]	Minimum	Maximum
NK Score[b]	10.93 ± 2.06	6	15
BMI[c]	17.85 ± 4.47	10.57	52.63
PACER Laps[d]	26.58 ± 16.45	2	120
Average Steps	4445.50 ± 1627.66	925	12563.25

[a]SD = Standard Deviation
[b]NK Score = Nutrition knowledge survey score
[c]BMI = Body Mass Index
[d]PACER Laps = Progressive Aerobic Capacity Endurance Run laps completed

Table 3. Linear model of predictors of nutrition knowledge survey scores with 95% confidence intervals reported in parentheses.

Variable (n=800)	b	SE[a] b	*p*
BMI[b]	0.05479 (0.02287, 0.08670)	0.01626	0.001**
PACER Laps[c]	0.01832 (0.00963, 0.02700)	0.00442	0.000***
Average Steps	−0.00011 (-0.00019, -0.00002)	0.00004	0.017*
Constant	9.93932 (9.16086, 10.71778)	0.39658	0.000***

Note: $R^2 = 0.037$
[a]SE = Standard Error
[b]BMI = Body Mass Index
[c]PACER Laps = Progressive Aerobic Capacity Endurance Run laps completed
*$p<0.05$ for significant prediction of nutrition knowledge survey scores
**$p<0.01$ for significant prediction of nutrition knowledge survey scores
***$p<0.001$ for significant prediction of nutrition knowledge survey scores

Table 4. Pearson's correlation coefficients among nutrition knowledge survey scores, BMI, PACER laps, and average steps.

	NK score[a]	**BMI[b]**	**PACER laps[c]**	**Average steps**
NK score[a]	1			
BMI[b]	0.107**	1		
PACER laps[c]	0.121***	−0.141***	1	
Average steps	−0.081*	−0.104**	0.105**	1

[a]NK Score = Nutrition knowledge survey score

[b]BMI = Body Mass Index

[c]PACER Laps = Progressive Aerobic Capacity Endurance Run laps completed

*$p<0.05$ for significant prediction of nutrition knowledge survey scores

**$p<0.01$ for significant prediction of nutrition knowledge survey scores

***$p<0.001$ for significant prediction of nutrition knowledge survey scores

activity knowledge test, and metabolic health measures. Due to outliers, 6 (5.6%) students were dropped from the data set, yielding data for 101 students. The remaining data were found to be approximately normal with homoscedasticity. Summary statistics for the total sample and by grade of each variable are shown in Table 5.

Higher nutrition knowledge survey scores were significantly associated with lower MetS scores (r=−0.247; p=0.010) and higher physical activity knowledge test scores (r=0.458; p<0.001) (Table 6). Grade level was also found to be a statistically significant (p=0.016) predictor of nutrition knowledge survey scores, showing that as school grade increased, nutrition knowledge survey scores increased as well. This regression model showed that the variables of metabolic health (MetS scores), physical activity knowledge (PAK score), and grade accounted for 29.1% of the variation of the nutrition knowledge survey scores (Table 6). A Pearson's correlation test was conducted with all variables that constitute the MetS score, and only two variables were statistically significant in predicting nutrition knowledge survey scores: HDL cholesterol (p=0.021) and waist circumference (p=0.020) (Table 7). A small effect size was seen between nutrition knowledge survey scores and HDL (r=0.229) as well as waist circumference (r=−0.231).

Table 5. Summary statistics for the total sample and by grade of nutrition knowledge survey scores, physical activity knowledge test scores, and metabolic syndrome scores (Means ± standard deviations, with ranges reported in parentheses).

	Overall	4th Grade	5th Grade	6th Grade
Observations	101	43	41	17
NK score[a]	11.77 ± 1.55	11.26 ± 1.42	11.98 ± 1.57	12.59 ± 1.42
	(8, 15)	(8, 14)	(9, 15)	(10, 14)
PAK score[b]	10.38 ± 4.00	8.47 ± 3.79	12.00 ± 3.41	11.29 ± 4.00
	(3, 21))	(3, 21)	(5, 19)	(5, 18)
MetS[c]	3.84 e-09 ± 3.36	−0.46 ± 3.08	0.30 ± 3.38	0.44 ± 4.01
	(−6.25, 9.14)	(−6.25, 9.14)	(−6.14, 7.24)	(−4.82, 6.94)

[a]NK score = Nutrition Knowledge survey score
[b]PAK score = Physical Activity Knowledge test score
[c]MetS = Metabolic Syndrome Score

Table 6. Linear model of predictors of nutrition knowledge survey scores with 95% confidence intervals reported in parentheses.

Variable (n=101)	b	SE[a] b	*p*
PAK Score[b]	0.137 (0.066, 0.208)	0.036	0.000**
MetS[c]	−0.105 (-0.185, -0.026)	0.040	0.010*
Grade	0.479 (0.092, 0.866)	0.195	0.016*
Constant	8.078 (6.339, 9.817)	0.876	0.000**

Note: $R^2 = 0.291$
[a]SE = Standard Error of the coefficient b
[b]PAK Score = Physical Activity Knowledge test score
[c]MetS = Metabolic Syndrome score
*p<0.05 for significant prediction of nutrition knowledge survey scores
**p<0.001 for significant prediction of nutrition knowledge survey scores

Table 7. Pearson's correlation coefficients among nutrition knowledge survey scores, and physical activity knowledge test scores, metabolic syndrome score, total cholesterol, HDL, triglycerides, LDL, glucose levels, waist circumference, and mean arterial pressure.

	NK score[a]	**PAK score[b]**	**MetS[c]**	**TC[d]**	**HDL[e]**	**TG[f]**	**LDL[g]**	**GLU[h]**	**WC[i]**	**MAP[j]**
NK score[a]	1									
PAK score[b]	0.458***	1								
MetS[c]	−0.247*	−0.122	1							
TC[d]	−0.041	−0.076	0.265**	1						
HDL[e]	0.229*	0.139	−0.712***	−0.004	1					
TG[f]	−0.101	−0.083	0.659***	0.377***	−0.383***	1				
LDL[g]	−0.078	−0.125	0.315**	0.892***	−0.266**	0.167	1			
GLU[h]	−0.153	−0.148	0.565***	0.261**	−0.285**	0.245*	0.291**	1		
WC[i]	−0.231*	−0.062	0.803***	0.171	−0.465***	0.435***	0.201*	0.247*	1	
MAP[j]	−0.117	0.022	0.622***	0.078	−0.260**	0.153	0.130	0.125	0.554***	1

[a]NK score = Nutrition Knowledge survey score
[b]PAK score = Physical Activity Knowledge test score
[c]MetS = Metabolic Syndrome Score
[d]TC = Total Cholesterol levels
[e]HDL = HDL cholesterol levels
[f]TG = Triglycerides levels
[g]LDL = LDL cholesterol levels
[h]GLU = Blood Glucose levels
[i]WC = Waist Circumference
[j]MAP = Mean Arterial Pressure
*$p<0.05$ for significant prediction of nutrition knowledge survey scores
**$p<0.01$ for significant prediction of nutrition knowledge survey scores
***$p<0.001$ for significant prediction of nutrition knowledge survey scores

DISCUSSION

Nutrition knowledge survey scores increased significantly from the initial test in January 2015 to the retest date in May 2015 following the CSPAP intervention. Significant increases were seen in each domain as well as total score. Similar to other studies, these findings indicate, as hypothesized, that a school-based intervention focused on nutrition and physical activity, such as the CSPAP, is effective in increasing knowledge in elementary school students.[10, 14, 22, 23] Gower et al. assessed nutrition knowledge in a less diverse and higher socioeconomic population of elementary school students.[24] Using one-sample t-tests, we found that total scores, as well as all domain scores, at both the initial test and the retest, were significantly lower ($p<0.001$) in this study than in the Gower et al. study. For these study samples, this comparison indicates that minority, low socioeconomic status populations have a lower baseline level of nutrition knowledge than higher socioeconomic status populations.[24] Collectively, these findings support the importance of implementing nutrition and physical activity school-based intervention programs into low socioeconomic elementary schools. These programs would provide an opportunity for schools to address the nutrition knowledge gap and the increased risk of obesity and other health complications prevalent in this population.[6, 12, 13, 18-21]

Increased nutrition knowledge had a significant positive relationship with aerobic capacity and body composition, and a significant negative relationship with physical activity. As hypothesized, increased nutrition knowledge survey scores correlated with an increase in PACER laps completed, although the effect size was small. Contrary to the hypothesis, this study did not find a positive relationship with increased nutrition knowledge and physical activity, showing that as nutrition knowledge increased, the average number of steps per school day decreased. Also, the current study failed to find an inverse relationship between increased nutrition knowledge and body composition, showing that as nutrition knowledge survey scores increased, so did BMI. This regression model only accounted for 3.7% of the variation of nutrition knowledge survey scores, indicating an overall small effect size. These results are inconsistent with previous studies, which showed that increased nutrition knowledge has an essential role in preventing weight gain and developing improved physical activity habits.[10, 14, 19, 23] These unexpected results may be attributed to the range of grade levels, the varying attention spans of the students participating in the study, and the evaluation of school day physical activity, not habitual physical activity.

Higher nutrition knowledge scores were significantly associated with lower MetS scores and higher physical activity knowledge test scores. These results indicate that as nutrition knowledge increased, the risk of developing metabolic syndrome decreased. In accordance with the literature, these findings provide compelling evidence that increasing nutrition knowledge in minority, low socioeconomic elementary school students could have a meaningful impact on the metabolic health of students, emphasizing the need for action.[10, 14, 18, 19, 23] Across grade levels, nutrition knowledge survey scores and MetS scores increased with school grade, while physical activity knowledge test scores were highest in the 5th grade. Increasing MetS scores, indicating a higher risk of developing metabolic syndrome, highlight the importance of comprehensive school-based interventions in elementary school. For the individual components of the MetS score, only two variables were found to be significant predictors of nutrition knowledge survey scores, including HDL cholesterol levels and waist circumference. These results indicate that as nutrition knowledge survey scores increased, HDL cholesterol levels increased while waist circumference decreased. In addition, these results suggest that higher HDL cholesterol levels and lower waist circumferences could have a protective effect against metabolic syndrome and obesity.

The strengths of this research include the large sample size, the study population, and the number and type of health parameters assessed. The large sample size provides sufficient power to the analysis and comparisons, which allows for statistical significances to be observed. The minority, low socioeconomic status population provides an ideal population to evaluate the effect of nutrition knowledge on other health parameters, as well as the effect of a CSPAP intervention on nutrition knowledge in elementary school children. The number and type of health parameters in this program add strength to the study due to the high quality instruments employed. First, both the nutrition knowledge and physical activity knowledge assessments have been validated with similar age groups.[24, 29] Second, the PACER test is a validated tool used nationally to assess aerobic capacity.[28, 35-39] Third, the Cholestech LDX machines and the pedometers provide an accurate measurement of cardio-metabolic and step count data, respectively.[29, 41, 42]

The limitations of this study include the quasi-experimental and predictive cross-sectional research designs, a minimal nutrition intervention, the use of BMI as a body composition measure, and the nutrition knowledge survey validation for grades 1 through 4 only. The quasi-experimental design decreases the strength of the findings due to its inherent nature while the predictive cross-sectional study design does not allow causal relationships to be made. The CSPAP was just initiated during the time frame from January 2015 to May 2015, with a minimal nutrition intervention. In addition, BMI is not the most accurate measure of body fatness, primarily due to its inability to distinguish between fat and fat-free mass.[45] However, BMI shows a stronger association with fat mass at higher levels (BMI ≥85th percentile), as compared to normal BMI levels.[1, 4, 45] Finally, the nutrition knowledge survey is validated for children in grades 1 through 4, while the survey was administered to children in grades K-6 for the current study.[24]

To our knowledge, this is the first study to evaluate the relationships among nutrition knowledge, health-related fitness, physical activity knowledge, and metabolic health measures in low socioeconomic status and racial minority elementary school children. Given the increased risk of childhood obesity in low economic and minority populations, it was important to identify potential opportunities to intervene in the school setting that will have lasting impact in preventing obesity. This study provides a foundation for future research with the lower socioeconomic populations by identifying the impact of nutrition knowledge and education through the CSPAP approach in elementary school children on health-related fitness, physical activity knowledge, and metabolic health. Future research on the implementation and evaluation of comprehensive interventions is needed.

CONCLUSION

In this study, nutrition knowledge significantly increased in elementary school students in grades 1-4 in three Title I schools in the Salt Lake City River District after a minimal CSPAP intervention. In addition, this study showed that increased nutrition knowledge was related to lower MetS scores and higher physical activity knowledge. These results indicate that nutrition knowledge could have an important effect on the health of lower socioeconomic elementary school children, underlining the importance of nutrition and physical activity school-based interventions. These interventions can help empower students to increase their nutrition knowledge, develop better health-related habits, and possibly prevent obesity and other associated conditions.

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